Human Biometric Sensor Interaction (HBSI)

Latest Research and Process Model

International Center for Biometric Research

Thanks to the international team of researchers

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What is the Human Biometric Sensor Interaction Framework?

- Its not usability – that's defined as the ease of use and learnability of a human-made object (NIST, 150 9241-11:1998)
- Its not ergonomics – that's the study of peoples efficiency in their working environment
- Previous versions, dated 2003-2015 did attempt to address the intersection of the human and biometric system; however, the most recent version has progressed beyond usability and ergonomics.
- Its beyond usability and ergonomics
- **Today, the HBSI model provides real time situational awareness recommendations and feedback for users interacting with a biometric system**

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Our philosophy

Usability and Ergonomics have a role, but:

- Biometric systems are not just a fingerprint sensor or an iris sensor in a stand-alone environment
- Standardized metrics are difficult to define for all situations, whether that be use cases, operational and scenarios
- Today, many biometric deployments are a subset in a system of systems
- Usability models typically look at the role of the genuine user, impostors are difficult to test and evaluate
- **What use is usability analysis if it is not in real-time and actionable?**

The evolution of the model – 13 years of history

Year	Hand	Finger	Iris	Face	Dynamic Signature	Voice	General
2003				Illumination [2]			
2004			Mobile iris	Illumination [3], [4]	Different devices [5]		Environment [6]
2005	Co-rec study [7]	Age [8]					
2006	Height of hand geometry [9], [10], [11]	]Age [12]			Forgeries [13]		
2007	Habituation [14]	Force [15] Age [16] Finger location [17]					Perceptions [18] Interaction [19]
2008		Gender [20], Skin characteristics [21]					Advances [22]
2009		Training [23], Matching [24]					HBSI calculations [25] Ergonomic Design [26]
2010		Measurement [27], Force [28], Evaluation [29]	Iris and the Environment [30]				Definitional Framework [26]
2011	Hand alignment	Force finger interactions [31] Slap segmentation [32]	HBSI training	Detractors	Signature interaction errors [33] Forgery		Evolution of HBSI [34]
2012			Iris Recognition				ABC Gate Analysis
2013	Transaction Times [35]	Number of impressions [36]	Mobile eye recognition	On Mobile Devices		Related Voice data collection	
2014				Signature and User Acceptance [37]			
2015		Border Patrol Replication Booth built in ICBR	Border Patrol Replication Booth built in ICBR, Zach Moore Thesis [43]	Border Patrol Replication Booth built in ICBR			Use of Critical and Associated Tracking Points, HBSI Expansion [38] , Mobile Biometric Usability Assessment [39]
2016						Interaction evaluation of a mobile voice authentication system [40]	Development of a test harness for biometric data collection and validation [41], A Framework for Biometric and Usage Performance Assessment of Automated Border Control Processes [42]

1. Single modality → Multimodality
2. Changing designs (ergonomics?)
3. Manipulating single variables to improve image quality
4. Mobile devices (scenario and wild – wild difficult to observe)
5. Automatic classification of metrics based on presentation

HBSI Validation

- Work across a number of modalities and mobile biometrics, and the framework is modality agnostic
- We have used this model, not only on how an observer assesses the biometric user in a static environment but we have conducted multiple tests in the wild. We have now collected HBSI metrics on over 1,000 subjects in the mobile space over the last two years
- Over the past 13 years over 3,000 subjects have been processed through the various iterations of the HBSI models that were developed at Purdue University

The evolution of the framework – 13 years of history

General Model	Hand, Face, Iris, Fingerprint, Voice, Mobile	
Behavioral	Signature	
False Claim		
Attack		
Token		
Process	Attended Border Booth	Unattended Border Booth

HBSI in an operational / scenario environment

- **Scenario**

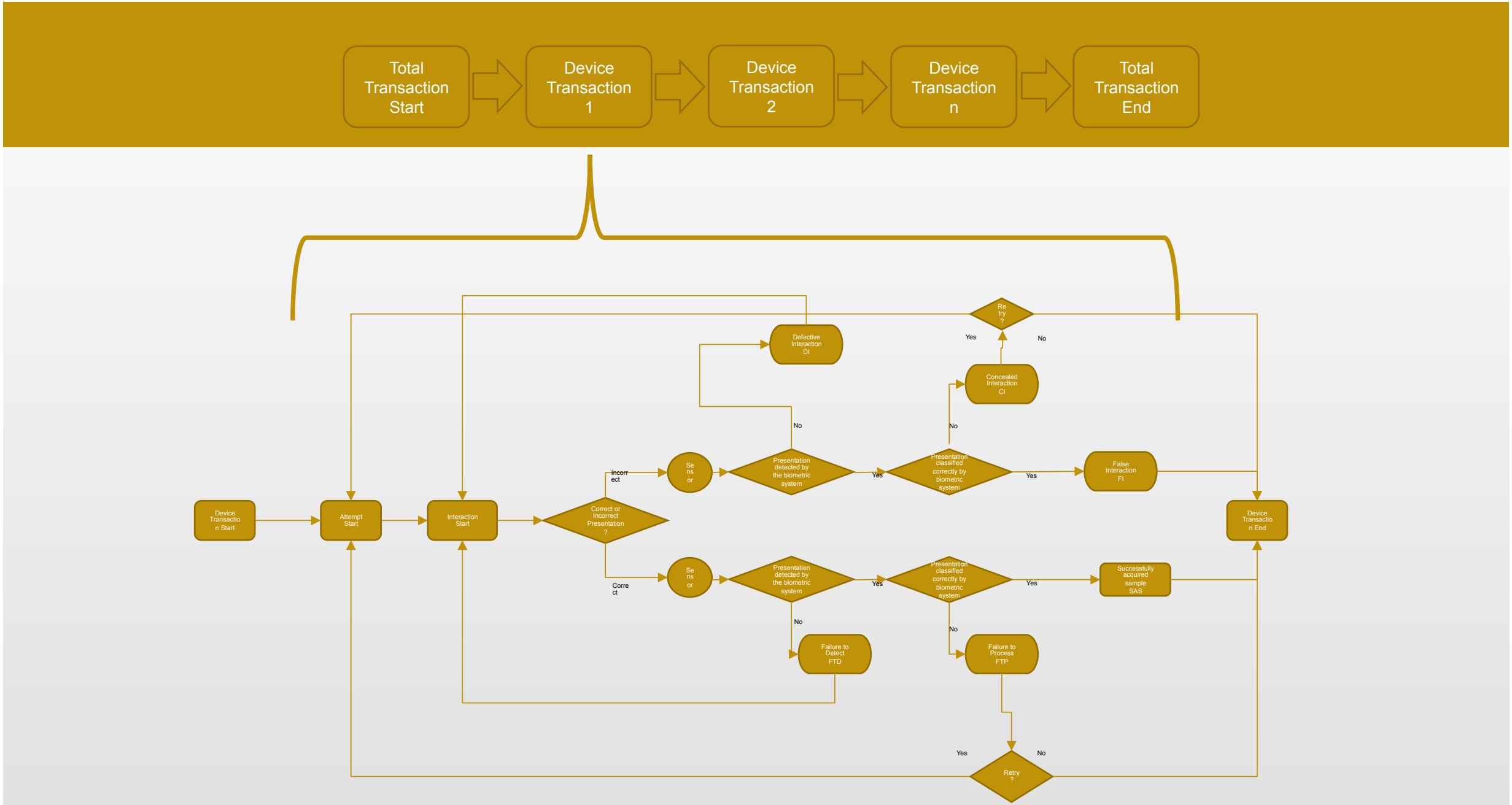
- **Model**
  - Operator
  - User
  - Environment
  - Baggage

Process HBSI

- Process HBSI model works for a number of different modalities – it is in fact user agnostic in terms of biometrics, or any technology. This could work for bar code scanners, passport readers and the like.
- The process HBSI model works for many scenarios, and was designed because of the processes associated with multi-interactions whether that be on a phone, PC, or in a complex system such as a kiosk

HBSI Unattended Kiosk

Behavior	Possible Systems Handling	HBSI	Notes
Unaware of the process, facing away from the camera	Biometric Presented	Defective Interactions	It is clear in this example that the user made an incorrect presentation
	Not Presented	False Interactions	
User understands where the camera is and is aware of where to look	Biometric Presented	Failure to detect, or SPS	In this example it is clear the user make a correct presentation
	Biometric not presented	Failure to Process	
User is distracted through interaction and loses focus on looking at the camera	Biometric Presented	Successfully Processed Samples, FTP	Cautious behaviors are difficult to classify as a correct or incorrect behavior.
	Biometric not presented	DI, CI, FI	


Total Transaction Start
Device Transaction 1
Device Transaction 2
Device Transaction n
Total Transaction End
Device Transactio n Start
Attempt Start
Interaction Start
Correct or Incorrect Presentation ?
Incorr ect
Se ns or
Presentation detected by the biometric system
Yes
No
Presentation classified correctly by biometric system
Yes
No
False Interaction FI
Defective Interaction DI
Re try ?
Yes
No
Concealed Interaction CI
Corre ct
Se ns or
Presentation detected by the biometric system
Yes
No
Presentation classified correctly by biometric system
Yes
No
Successfully acquired sample SAS
Failure to Detect FTD
Failure to Process FTP
Retry ?
Yes
No
Device Transactio n End

Model works for border environments

- Three different classifications of ABC systems (Frontex)
  - One-step process (token + identity + border crossing)
  - Integrated two-steps (token and eligibility, then identify)
  - Segregated two-step process (step 1, then a token or ticket, then step two)

Evaluation Points	Definition	Possible Outcome	HBSI categorization
Traveler Presence	Is the traveler's presence detected?	Yes, No (Reject / Assist)	FTD / DI
Token Presence	Is the token detected?	Yes, No (Reject / Assist)	FTD / DI
Token Read	Was the token successfully read?	Yes, No (Reject / Assist)	SPS, FTP / CI
Biometric Capture	What biometric data is required?	Identify Modality	All
Data Verification	At what point does identification take place?	Database / Local Level	Traditional Biometric metrics

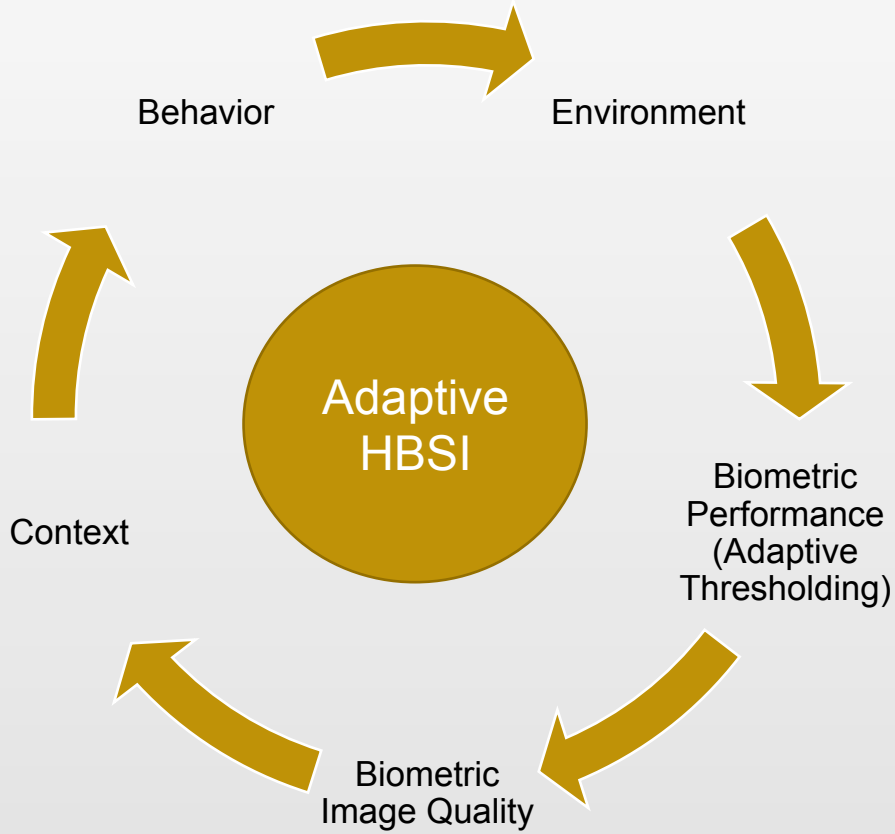
Building blocks of the HBSI framework

GOAL: Optimize the system

Pre Interaction	Predictive tools from research studies and prior data collections	Characteristics about the user from other document data - Passport	Connectors to other 3rd party data		
	HBSI metrics – tested and evaluated on many modalities	User behavior – through the use of primary and secondary tracking points		Environmental data (sensor networks and IoT)	Context
During Interaction			Feedback to the operator / subject / integrator	Biometric data from the system (IMQ, Performance)	
Post Interaction	Retraining of the system				

Adaptive HBSI

- The ability to influence the environment to enable the biometric system to optimally perform for an individual
  - Behavior
  - Context
  - Environment
  - Biometric performance
  - Biometric image quality

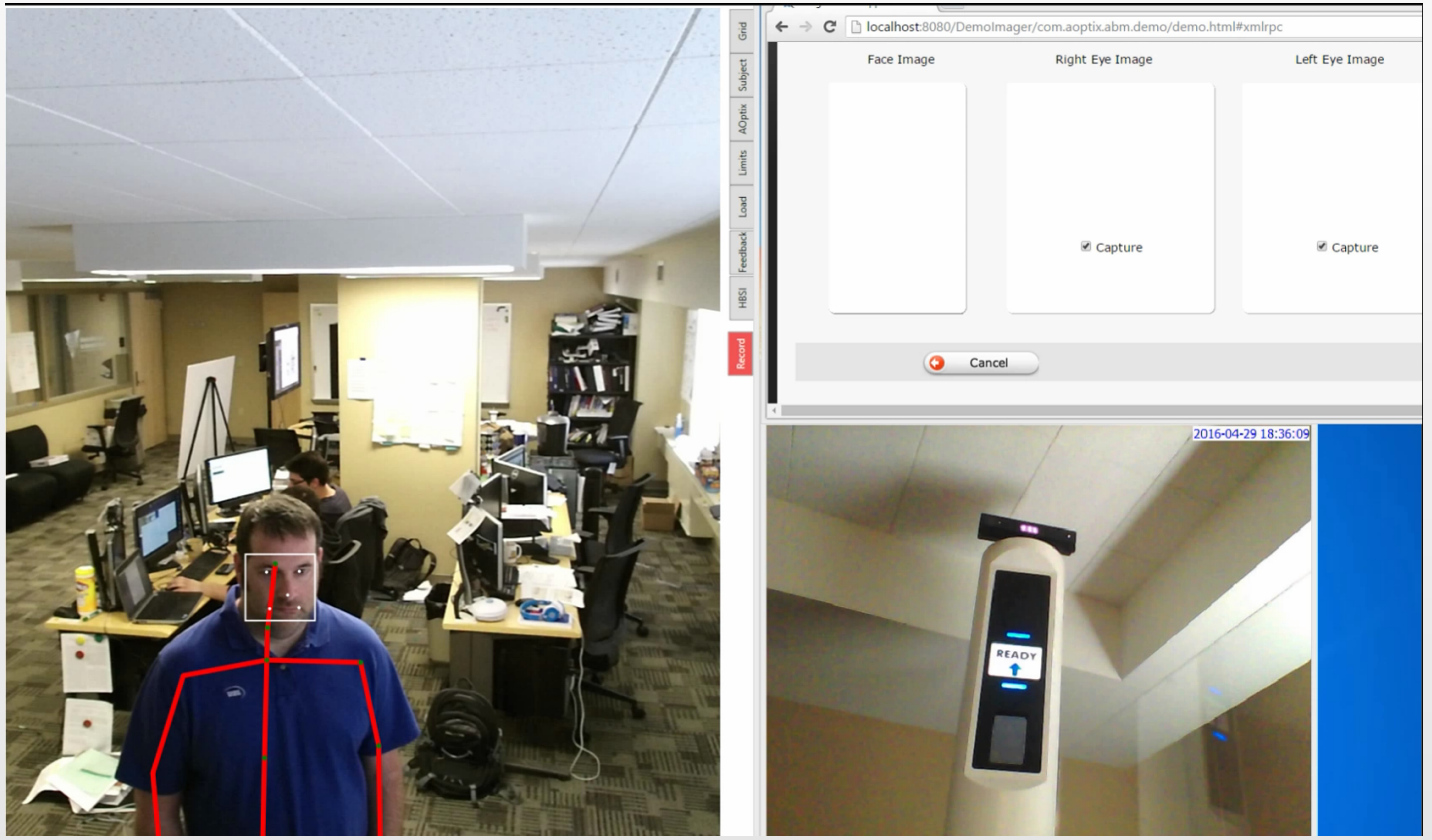


HBSI Model has grown beyond usability to increase situational awareness to modify user behaviors or adapt deployment parameters to increase user experience and optimize system performance

HBSI as part of the system

Scenario in the center

- Real time collection of metrics, including body (pose, angle etc.), face expression, environmental (light, noise etc.), sensor actions, and biometric measurements.
- As this is part of a system (not just the biometric), these metrics are standalone, and not a function of the biometric performance.
- Reacting to the metrics will illustrate how the biometric component of the system works



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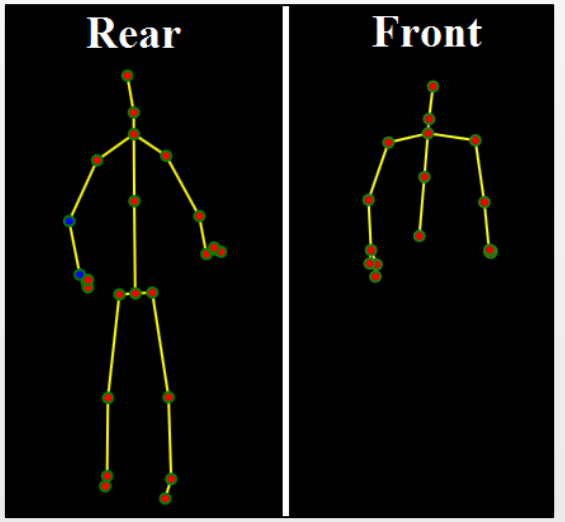
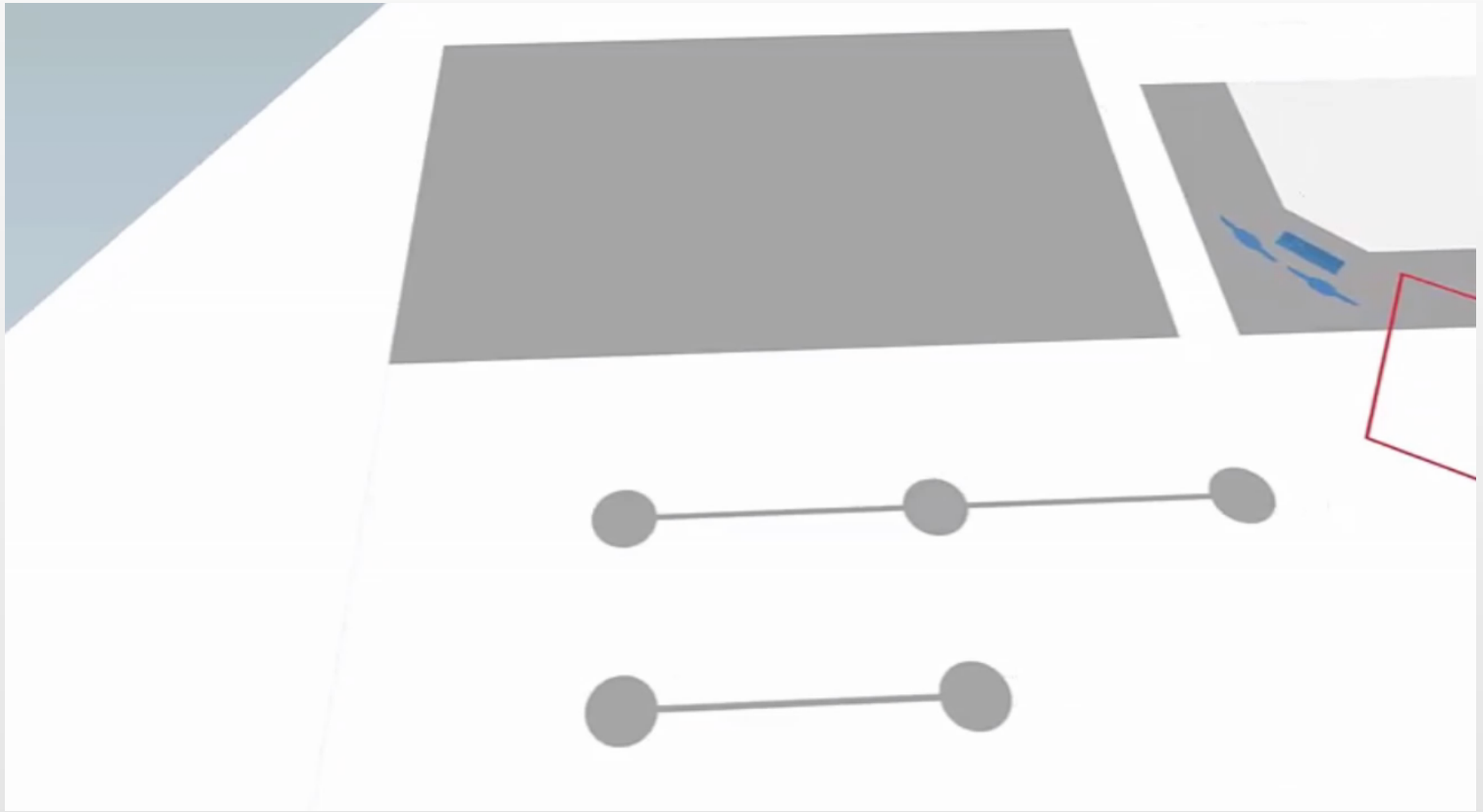
Scenario Evaluations – Critical and Associated Tracking

Transaction Luggage Combination

1. Backpack
2. Large Roller
3. Medium Roller
4. Small Duffel
5. Large Duffel
6. Backpack + Large Roller
7. Backpack + Medium Roller
8. Backpack + Small Duffel
9. Backpack + Large Duffel
10. Small Duffel + Large Roller
11. Large Duffel + Large Roller
12. Large Duffel + Small Duffel
13. No Luggage

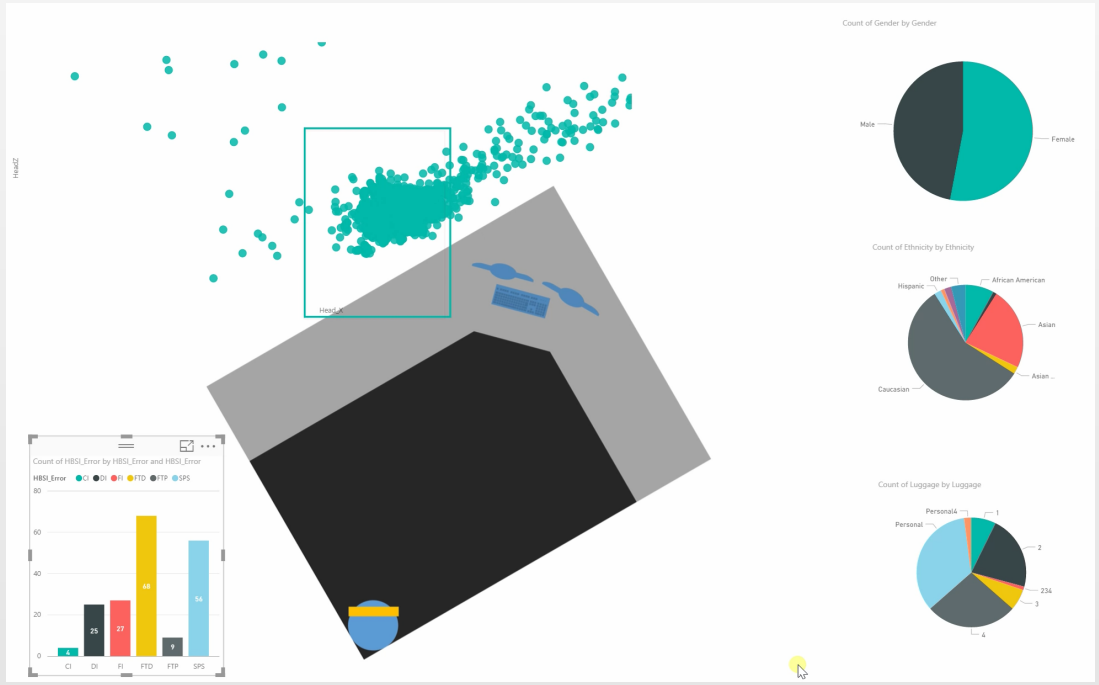


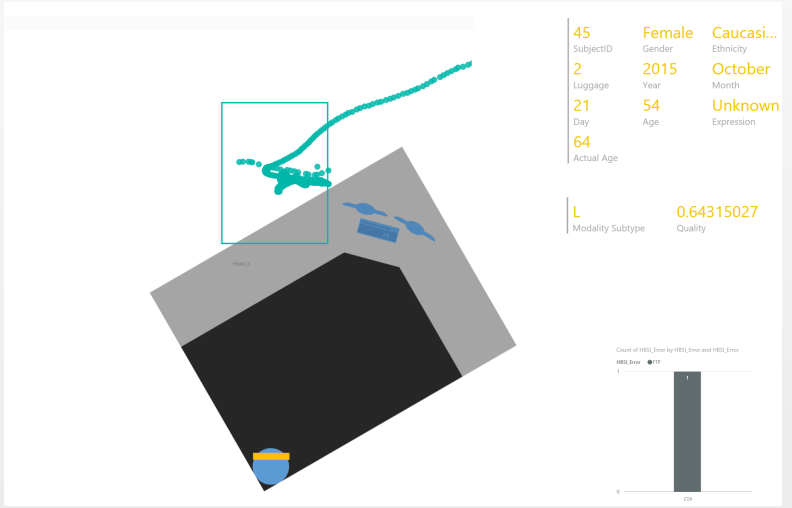
Border control scenario

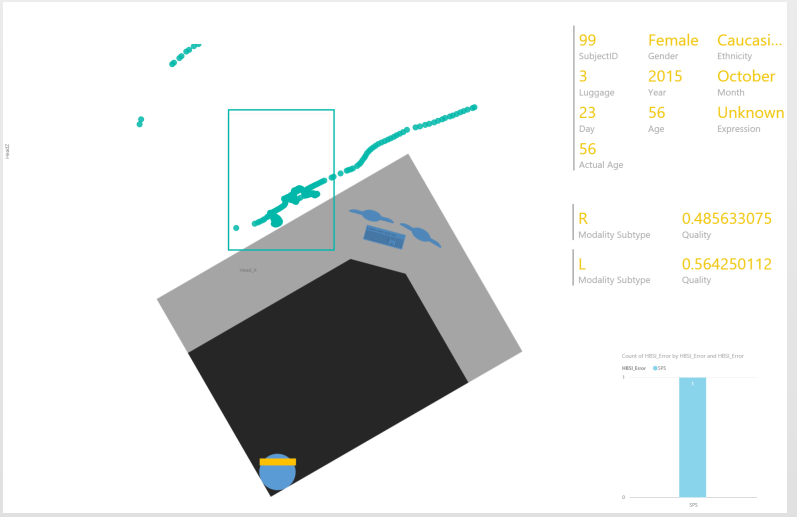


- Subject patterns through the booth (estimate metrics such as throughput impacts)
- Global view of HBSI metrics, automatically segmented in real-time
- Intuitive visualization

Detailed information about the subject







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Real-time data about individuals within the system

- Distribution of HBSI metrics, can then be tied into the traditional biometric metrics
- Here we see the distribution of iris image quality and iris recognition errors
- We can do this on any number of modalities

HBSI model (Current Work)

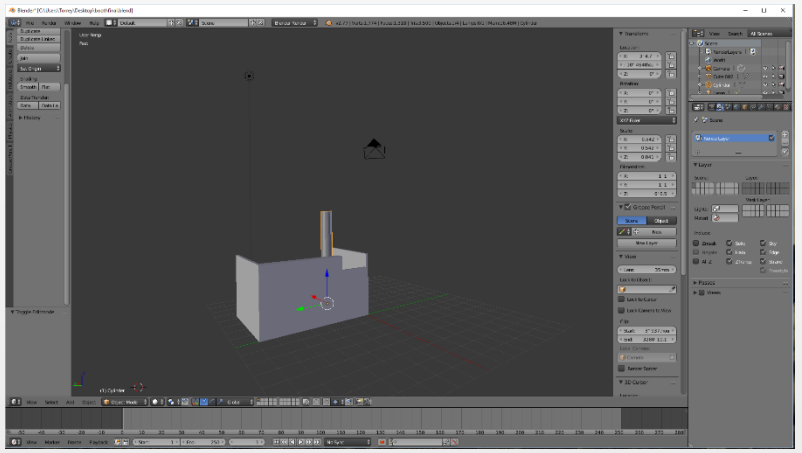
- Cloud-based
- Mobile apps developed (iOS, Android, Windows)
- Natural language queries
- Real-time feedback
- Dashboards for actionable data
- Visualization regardless of metric philosophy

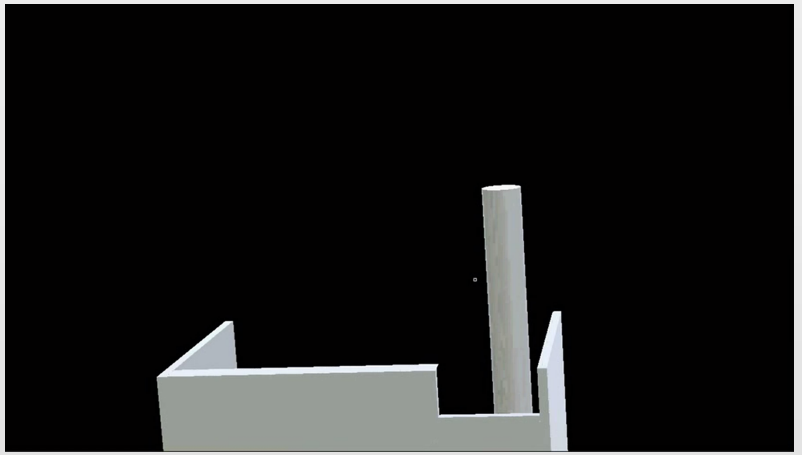
Education and Training

- The HBSI model developed at Purdue University has examined the HBSI models, and we have now provided access to our models online
- The next step we are working on is to demonstrate the usability issues that people face in a mixed reality

HBSI Mixed Reality using HoloLens

- Visualize from the data from different perspectives (users, operators, integrators)
- Immerse researchers into the flow of the operation to assess the changes in performance of the biometric system (dry runs)
- Alter the environment for testing and evaluation
- Potential for anomaly and behavior detection to support risk and decision sciences
- Training purposes





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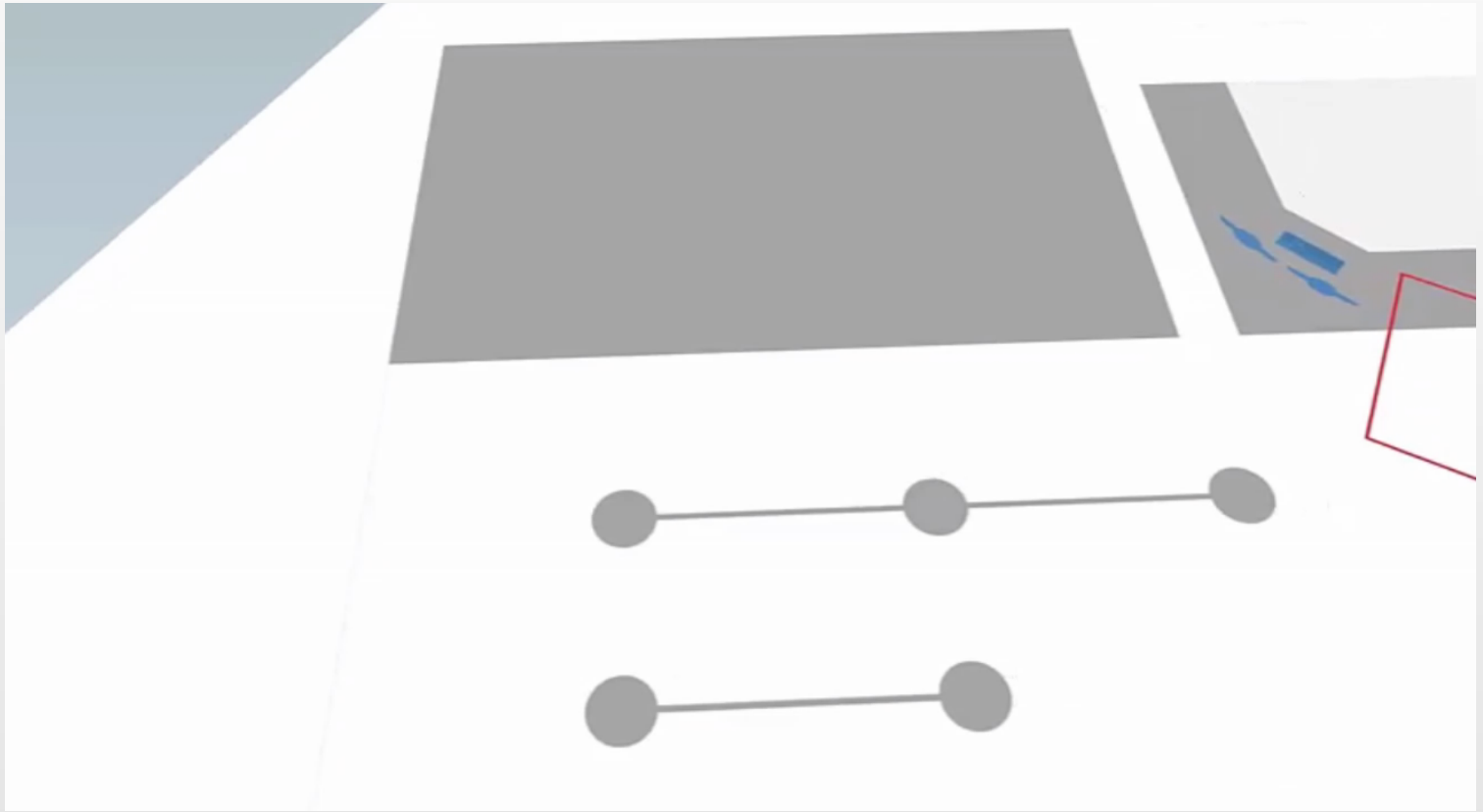

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HBSI: Beyond Usability

Learn more at hbsi.icbrpurdue.org

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Any Questions

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